



Systems Thinking

NDIA SYSTEMS ENGINEERING
CONFERENCE

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What is a system?

- A definition as offered by Gregory Watson in his book, *Business Systems Engineering*: “**System means a grouping of parts that operate together for a common purpose.**” (Watson, 1994).

What is a System? (Cont'd)

- Definition as adapted from Random House Dictionary: A **system** is an assemblage or combination of elements or parts forming a complex or unitary whole, such as a river system or a transportation system; any assemblage or set of correlated members, such as a system of currency; an ordered and comprehensive assemblage of facts, principles, or doctrines in a particular field of knowledge or thought, such as a system of philosophy; a coordinated body of methods or a complex scheme or plan of procedure, such as a system of organization and management; any regular or special method of plan or procedure, such as a system of marking, numbering, or measuring (Blanchard & Fabrychy, 1998).

What is Thinking?

- What, precisely, is *thinking*? When at the reception of sense impressions, memory pictures emerge, this is not yet *thinking*. And when such pictures form a series, each member of which calls forth another, this too is not yet *thinking*. When, however, a certain picture turns up in many such series, then—precisely through such return—it becomes an ordering element for such series... Such an element becomes an instrument, a concept. I think the transition from free association of *dreaming* to thinking is characterized by the more or less dominating role which the *concept* plays in it (Einstein, in Schilpp, 1949).

Connectedness

- “If you wish to understand a system, and so be in a position to predict its behavior, it is necessary to study the system as a whole. Cutting it up into bits for study is likely to destroy the system’s connectedness, and hence the system itself.” (Sherwood, 2002)

Connectedness

- “If you wish to influence or control the behavior of a system, you must act on the system as a whole. Tweaking it in one place in the hope that nothing will happen in another is doomed to failure—that’s what connectedness is all about.”
(Sherwood, 2002).

Systems Theory

- General Systems Theory
- Chaos Theory
- Quantum Theory
- Ecological Theory

Systems Principles

- Openness
- Purposefulness
- Multidimensionality
- Emergent property
- Counterintuitiveness

Systems Thinking

- Problem Solving Tool
- Pioneered By Biologists
- Looks At The Whole View
- Reduces Complexity
- Controls System Behavior

Systems Thinking Methodologies

- Soft Systems Methodologies
- Hard Systems Thinking
- The Fifth Discipline

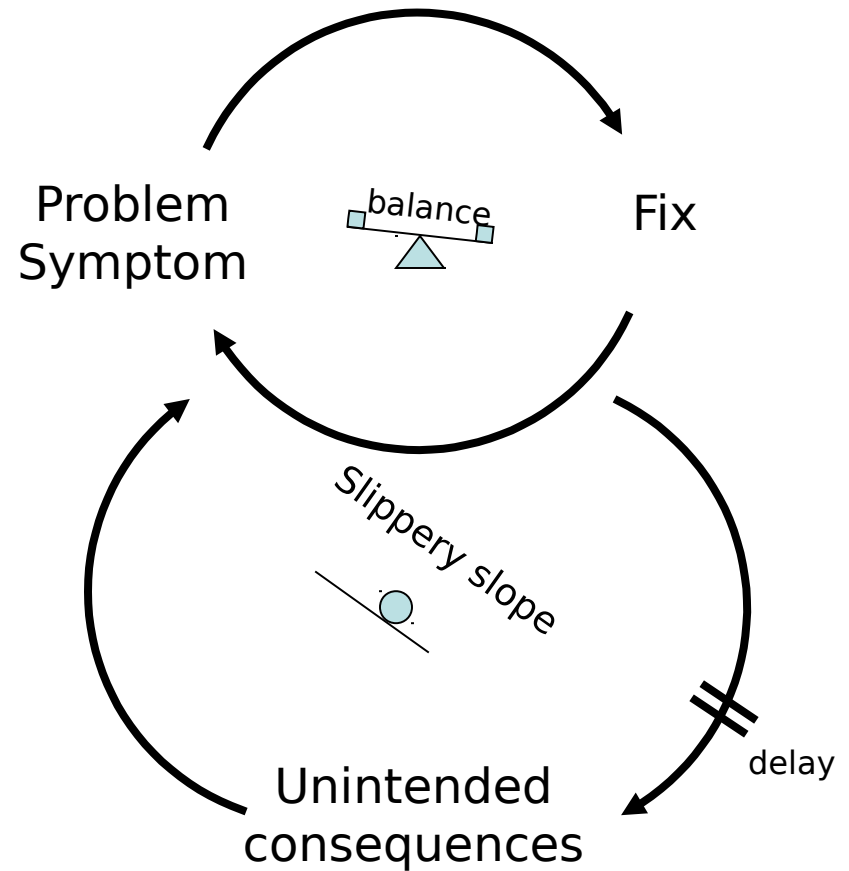
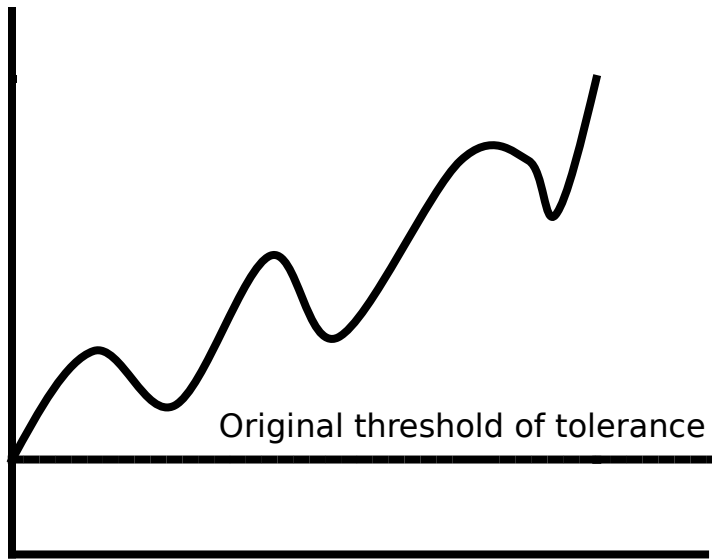
Systems Thinking Tools

- Archetypes
- Causal Loop Diagrams
- Stocks and Flows
- Simple Structure Dynamics

Systems Thinking Models

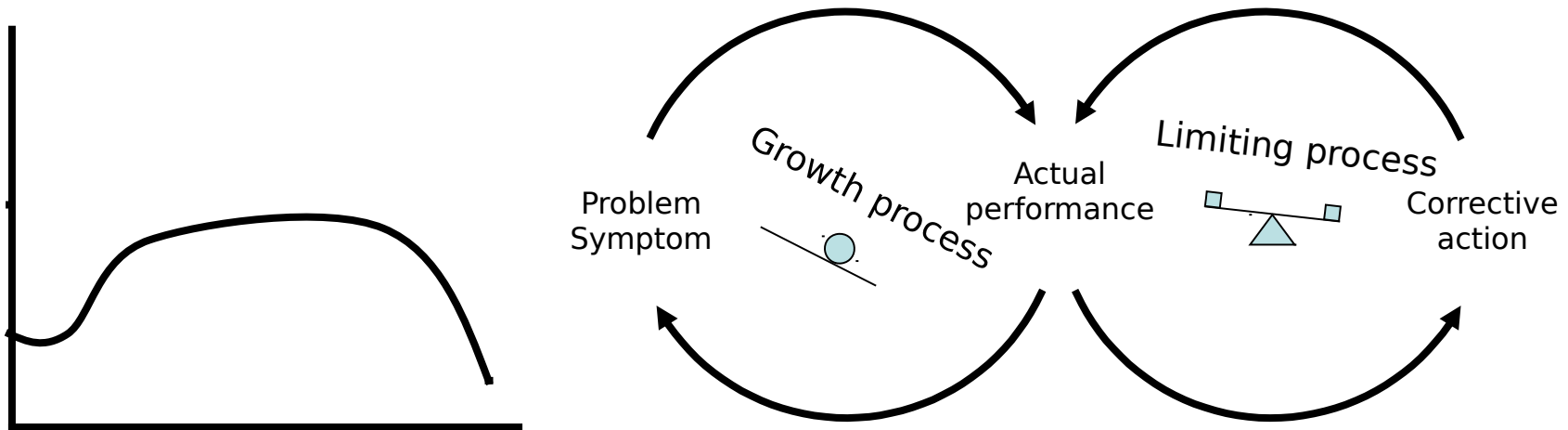
- Archetypes
- Causal Loop Diagrams
- Stocks and Flows

Archetype: Fixes That Backfire



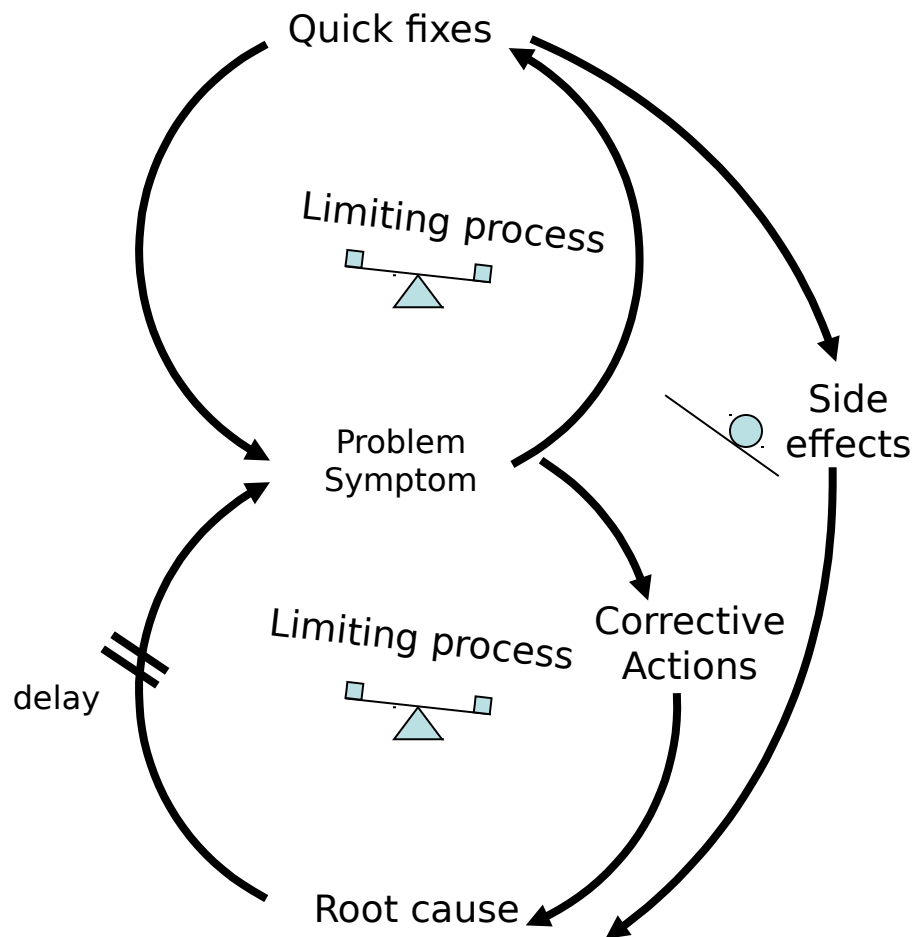
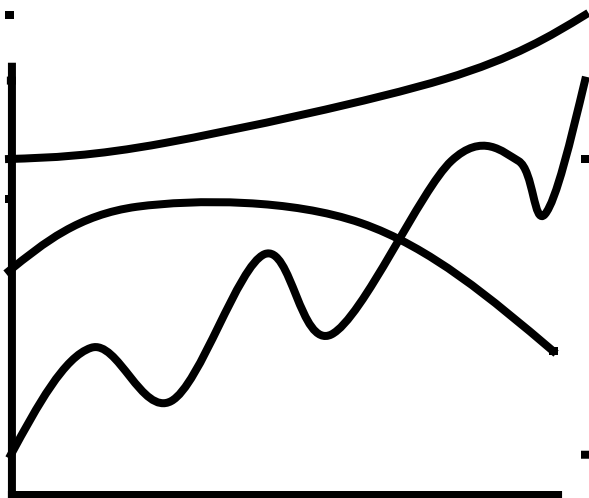
The problem symptom alternately improves. It goes down, then comes Back up again and usually comes back worse than before (Senge, 1994).

Archetype: Limits to Growth



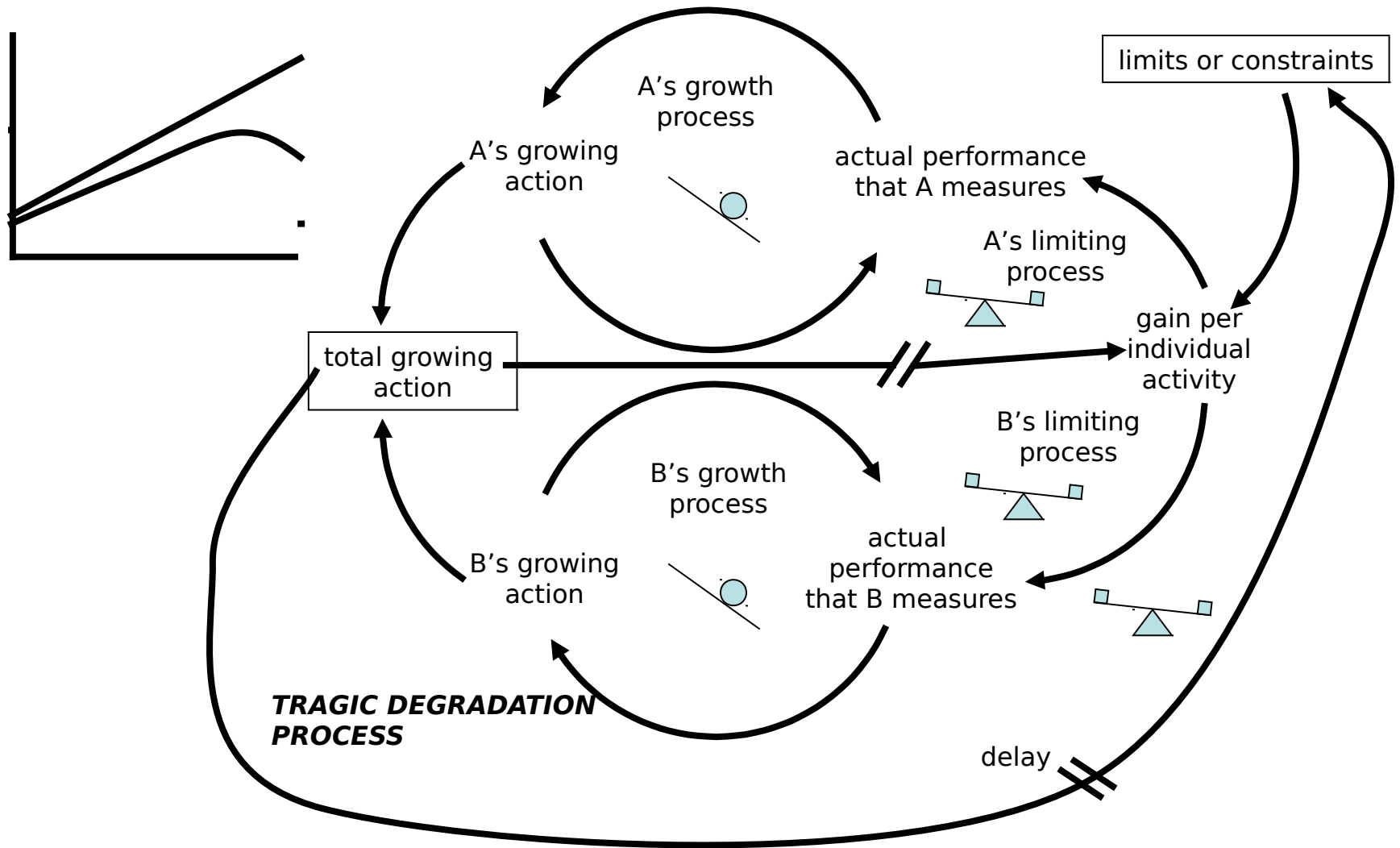
Growth occurs and sometimes dramatic but levels off and/or falls into decline (Senge, 1994).

Archetype: Shifting the Burden



Three patterns exist side by side. The reliance on short-term fixes grows stronger, while efforts to fundamentally correct the real problems grow weaker, and the problem symptom alternately improves and deteriorates (Senge, 1994).

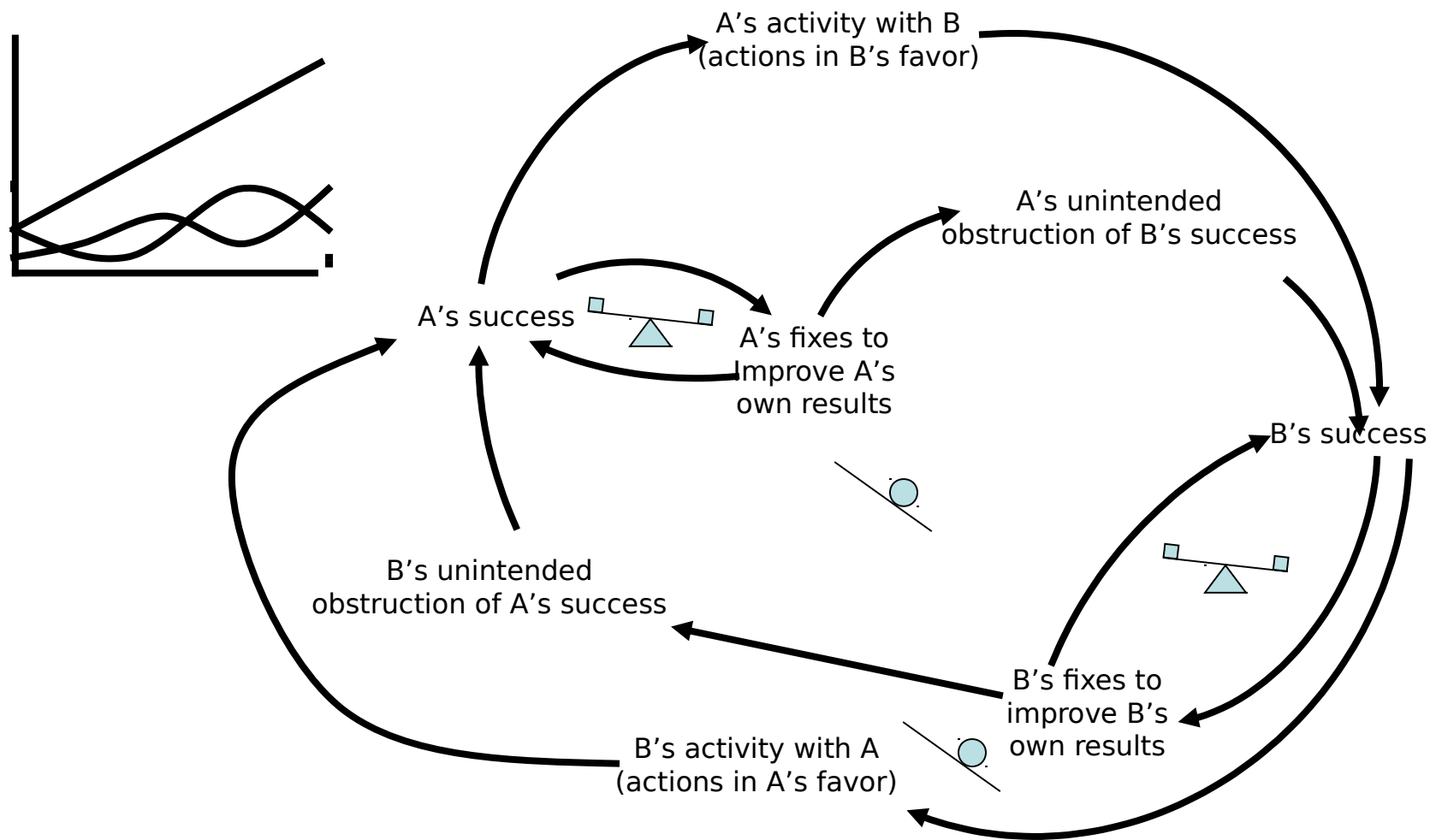
Archetype: Tragedy of Commons



Total activity grows, but the gains from individual activities are dropping off. Parts of the organization are suffering for the whole (Senge, 1994).

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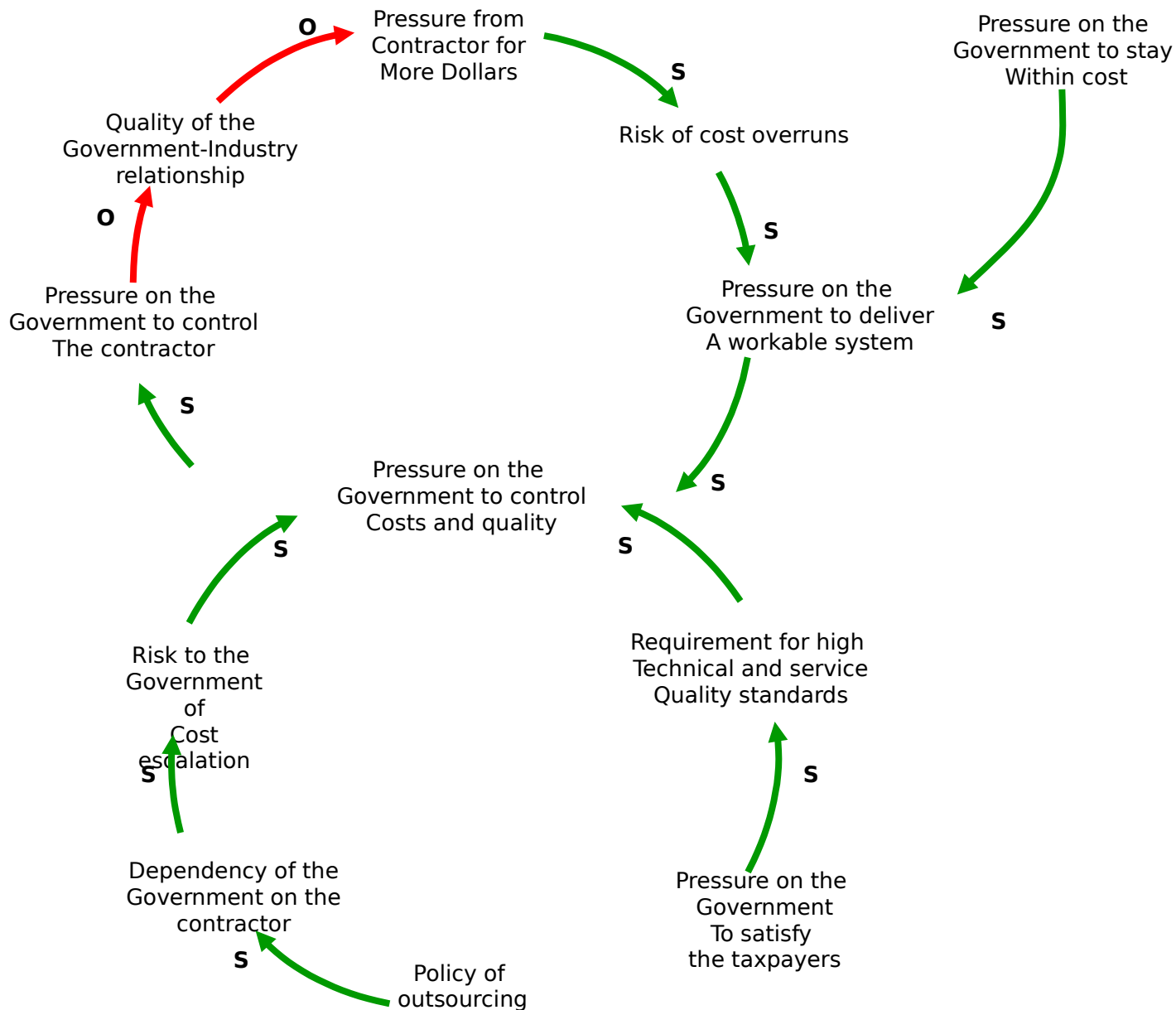
Archetype: Accidental Adversaries



Each side's performance either declines or stays level and low, while competitiveness increases over time (Senge, 1994).

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Causal Loop Diagrams



Government Cost Model Adapted From Sherwood's Causal Loop Diagrams

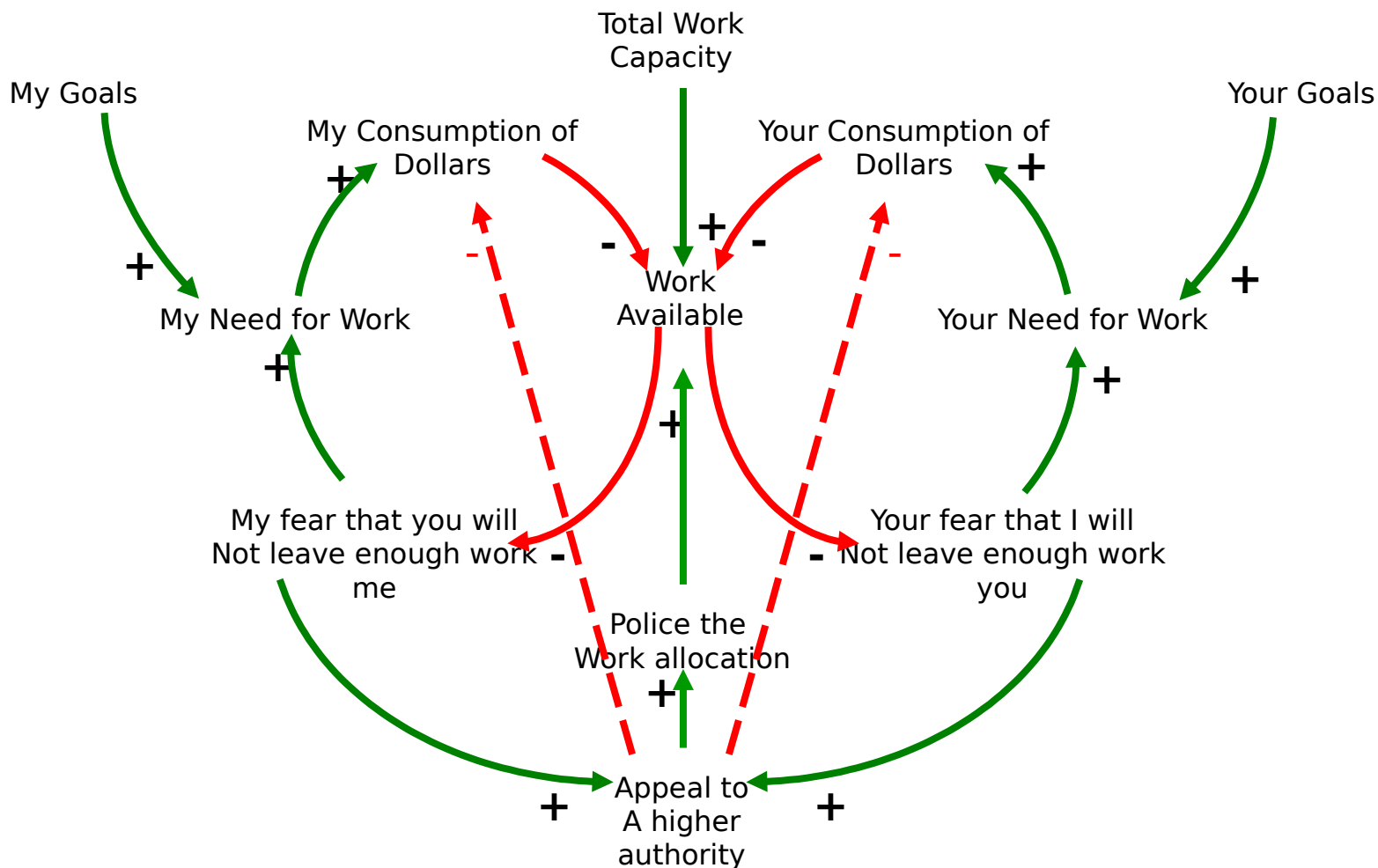
Causal Loop Diagram



Option 1: Two reinforcing loops (Sherwood, 2002)

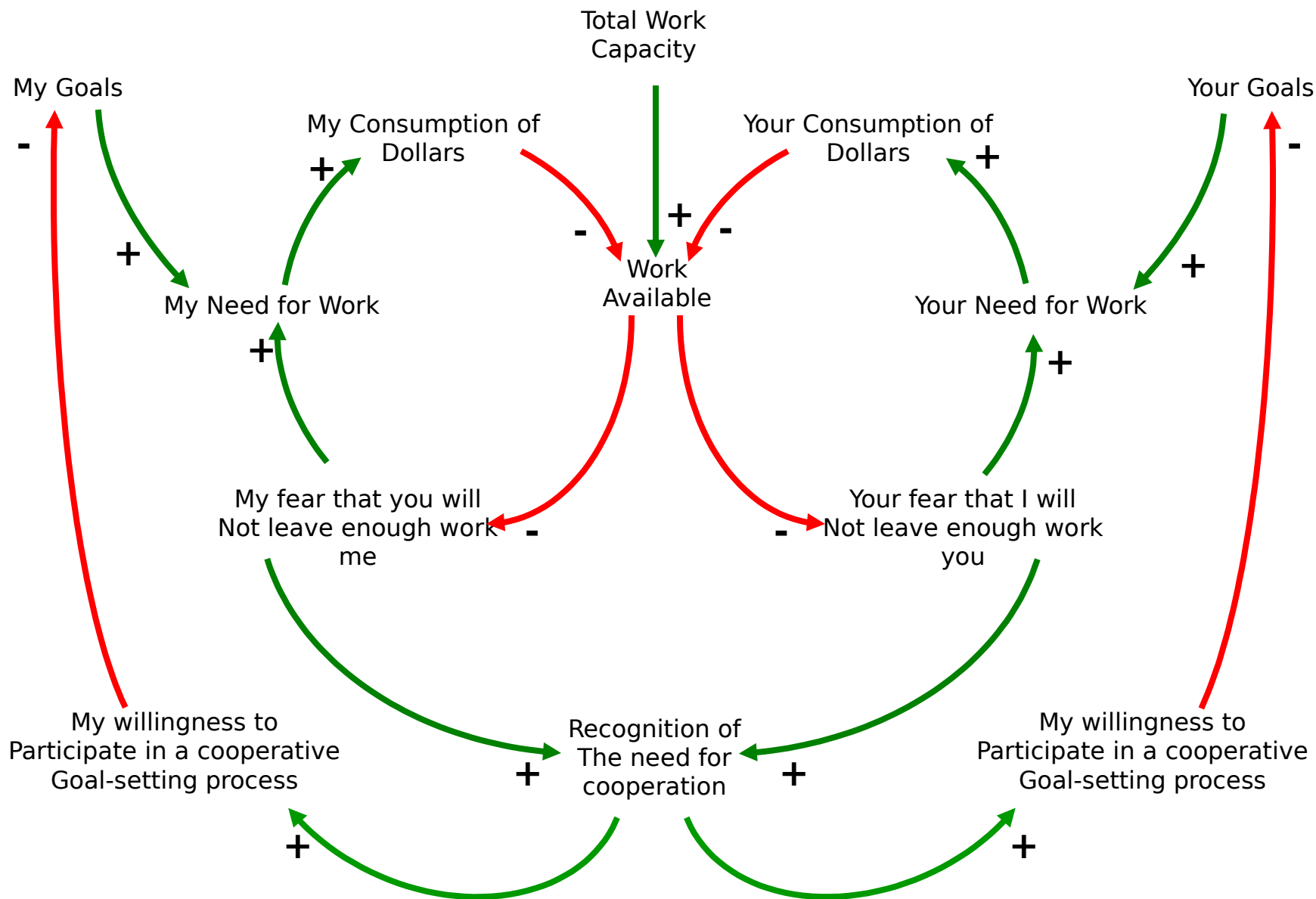
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Causal Loop Diagram



Option 2: Limit consumption—before turf war (Sherwood, 2002)

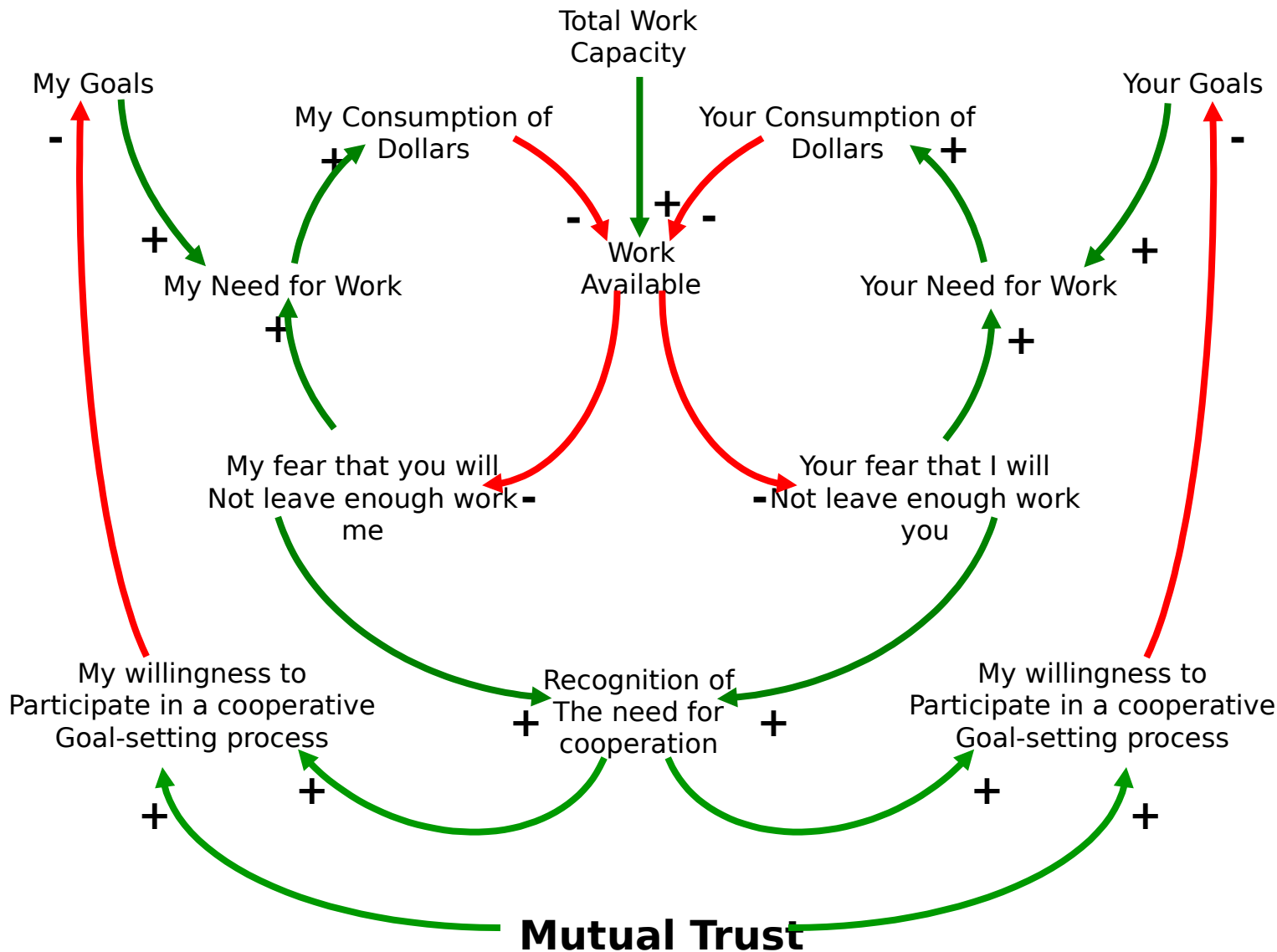
Causal Loop Diagram



Option 3: Players See the Sense in Cooperation (Sherwood, 2002)

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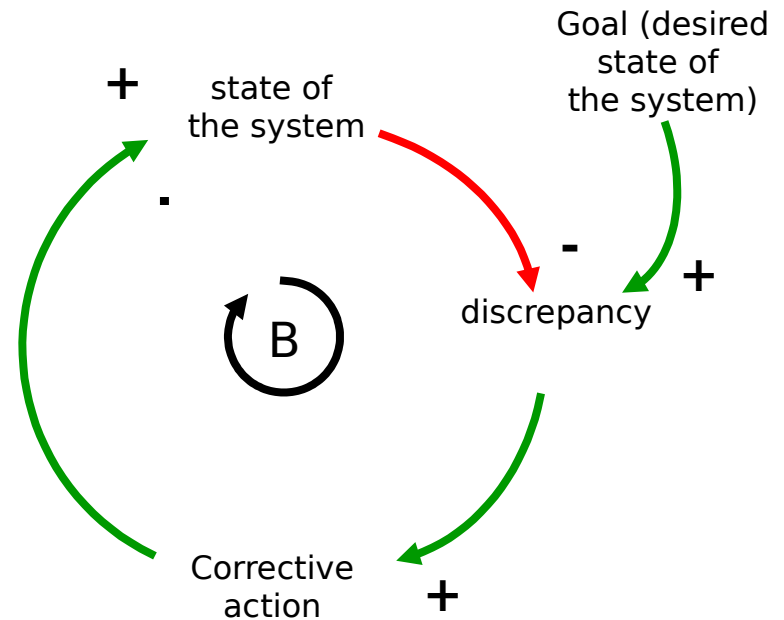
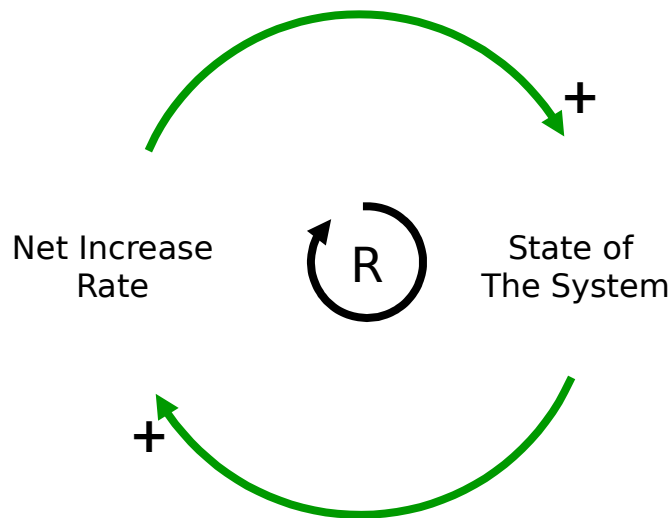
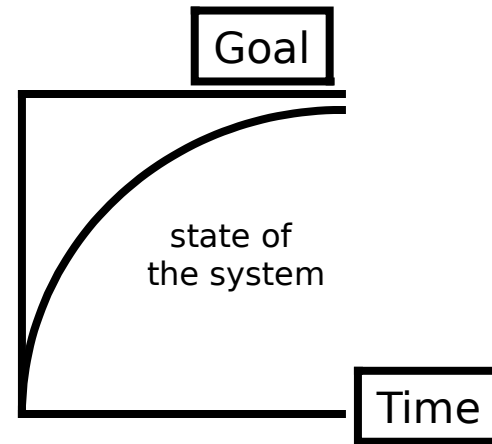
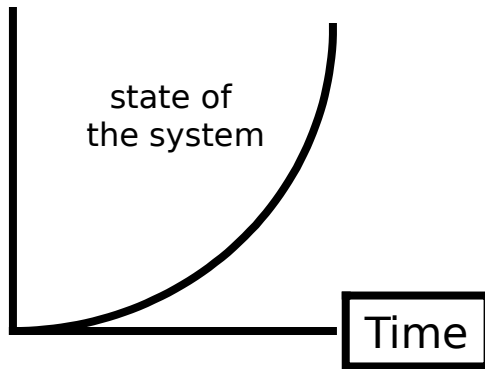
Causal Loop Diagram



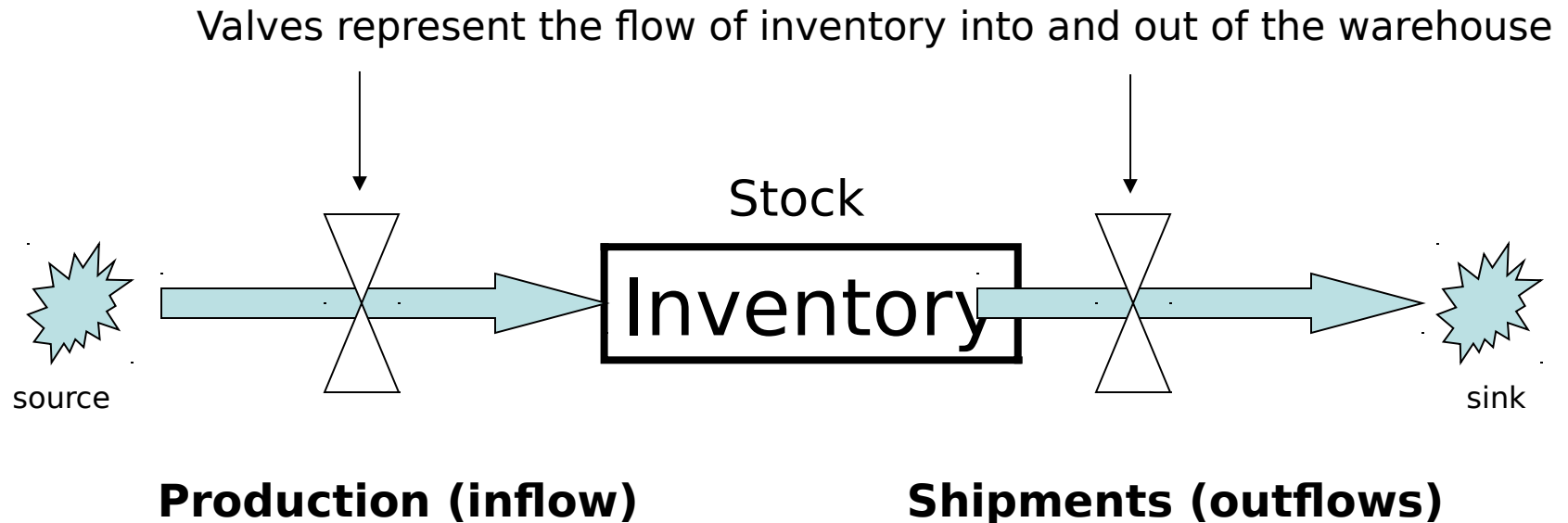
Best Solution: Goals Match—Combined Benefit!

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System Dynamics: Growth and Goal Seeking Structure and Behavior



Stocks and Flows

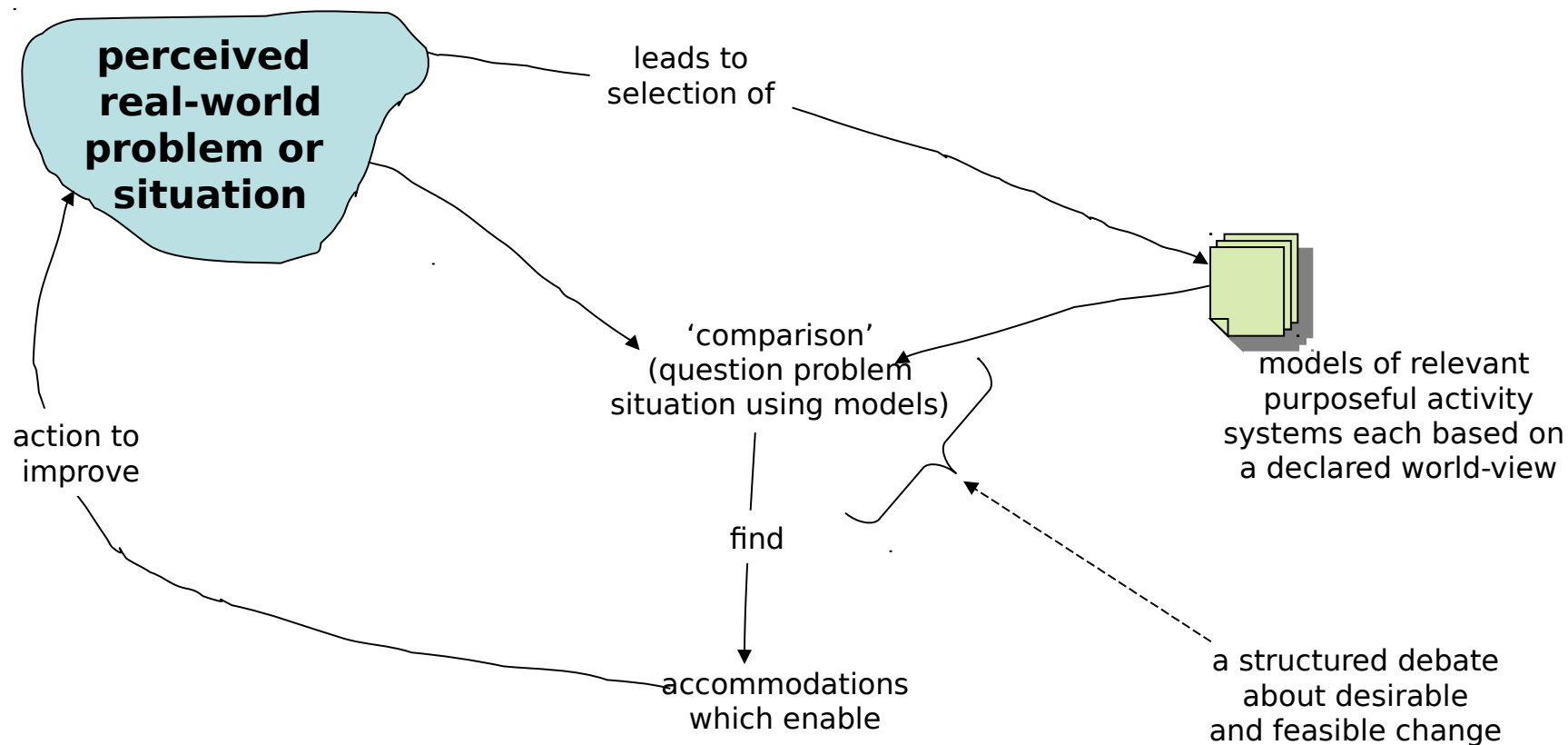


Sources and sinks are outside the model boundary.

Stocks and Flows are used in Causal Loop Diagrams to cover some of their limitations of not being able to capture stocks and flows within systems (Sterman, 2000).

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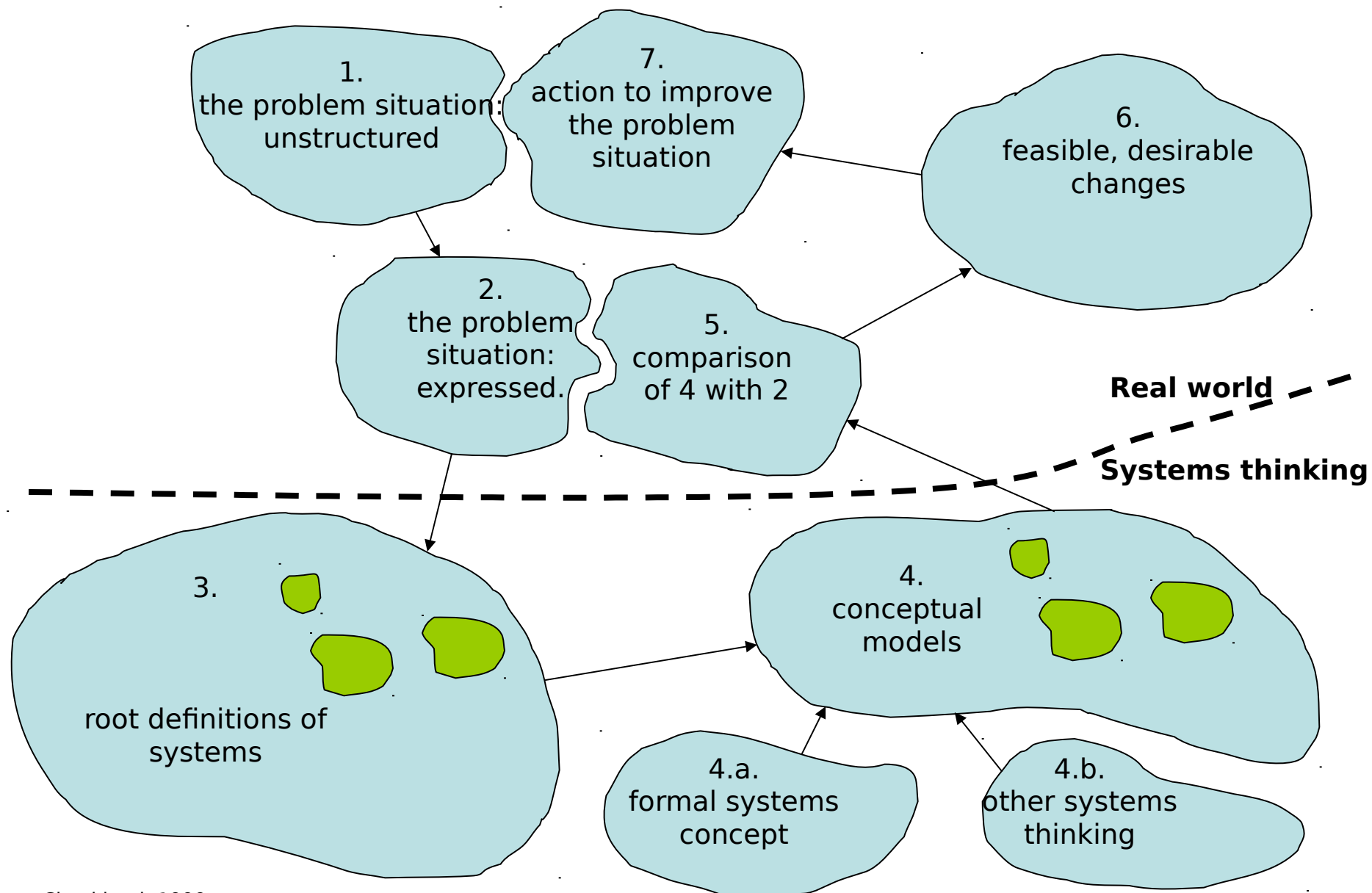
Some Models from Soft Systems Methodology--Checkland

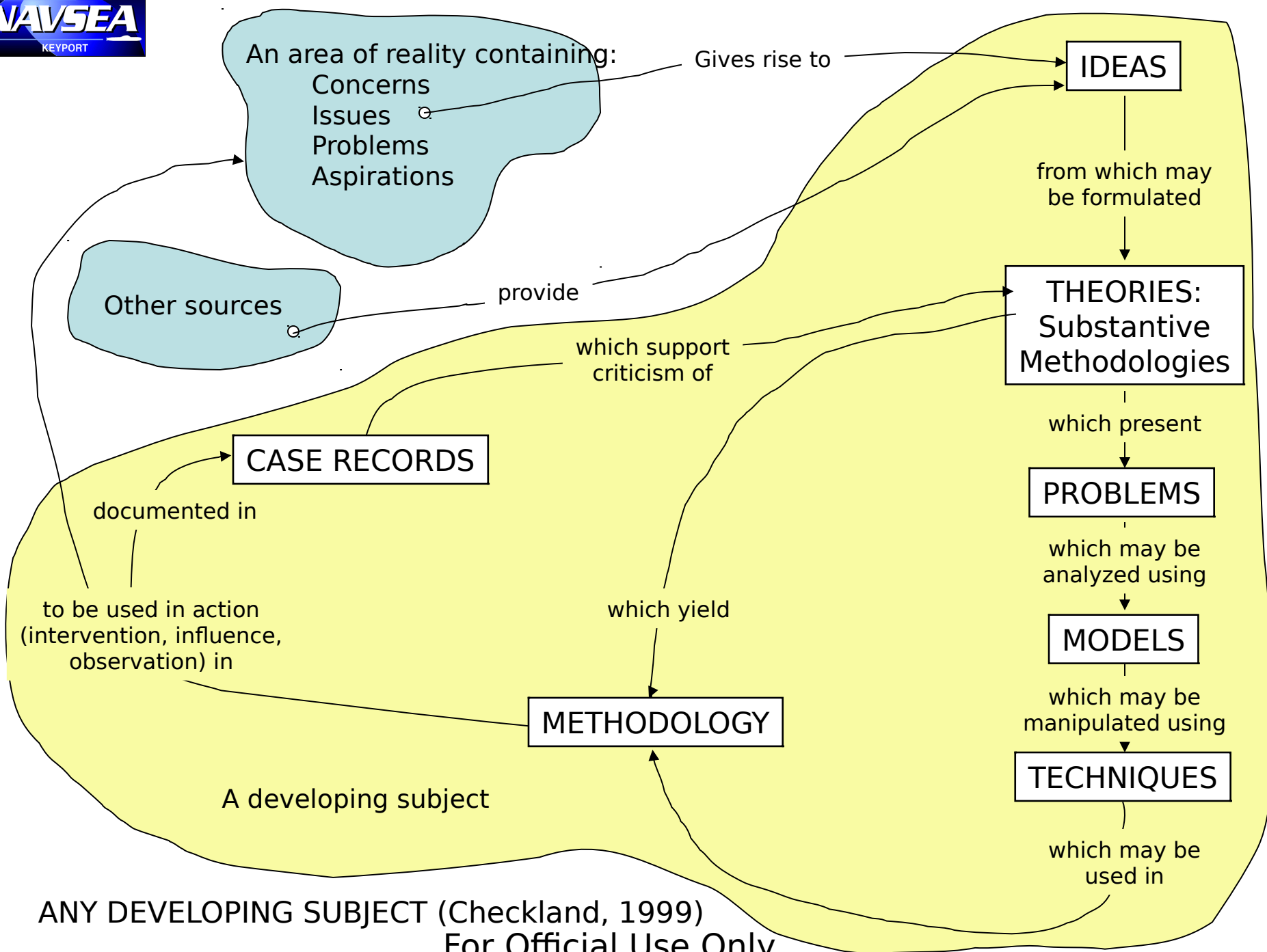


Principles

- real world: a complexity of relationships.
- relationships exploded via models of purposeful activity based on explicit world visions.
- inquiry structured by questioning perceived situation using the models as a source of questions.
- 'action to improve' based on finding accommodations (versions of the situation which conflicting interests can live with)
- inquiry in principle never-ending; best conducted with wide range of interested parties; give the process away to people in the situation.

Method for Unstructured Problems





Laws of Systems Thinking

- Today's problems come from yesterday's solutions.
 - Moving the problem around.
- The harder you push, the harder the system pushes back.
 - Compensating feedback.
- Behavior grows better before it grows worse.
- The easy way out usually leads back in.
- The cure can be worse than the disease.
- Faster is many times slower.
- Cause and effect are not closely related in time and space.
- Small changes can produce big results—but the areas of highest leverage are often the least obvious.
- You can have your cake and eat it too, but not at the same time.
- Dividing the elephant in half does not produce two small elephants.
- There is no blame.

Senge, 1990

Questions?

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